January 1996

Physics 30

Grade 12 Diploma Examination

Alberta
EDUCATION

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Physics 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

Total possible marks: 70

- 37 multiple-choice and 12 numerical-response questions, of equal value, worth 70% (49 marks) of the examination
- 2 written-response questions, worth a total 30% (21 marks) of the examination

This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

Tear-out data sheets are included near the back of this booklet.

The blank perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Read each question carefully.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. biology
B. physics
C. chemistry
D. science

Answer Sheet

Ⓐ ● Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

Examples

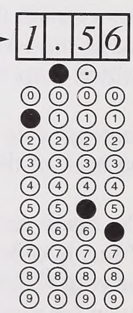
Calculation Question and Solution

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass would be _________ m/s^2.
(Round and record your answer to three digits on the answer sheet.)

$$a = \frac{F}{m}$$

$$a = \frac{121\ \text{N}}{77.7\ \text{kg}} = 1.5572716$$

Record 1.56 on the answer sheet ⟶



Correct Order Question and Solution

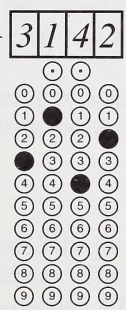
Place the following types of EMR in order or increasing energy:

1 blue light
2 gamma radiation
3 radio waves
4 ultra violet radiation

(Record your answer on the answer sheet □□□□.)

Answer: 3142

Record 3142 on the answer sheet →



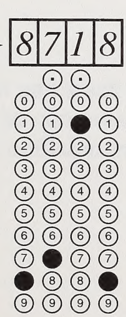
Scientific Notation Question and Solution

A hydrogen-like atom whose 3-2 transition emits light at 164 nm would have an E_1 value, expressed in scientific notation, of $-\boldsymbol{a.b} \times 10^{-cd}$ J. The values of *a*, *b*, *c*, and *d*, respectively, are _________.

(Round and record your answer on the answer sheet *a* *b* *c* *d*.)

Answer: 8718

Record 8718 on the answer sheet →

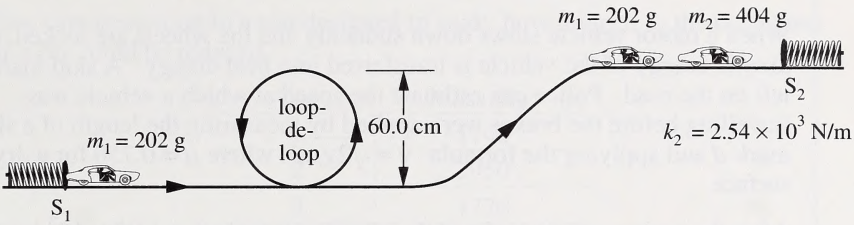


Written Response

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.
- Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

Do not turn the page to start the examination until told to do so by the presiding examiner.

Use the following information to answer the next three questions.



In the operation of a pinball machine, a toy car (m_1) is shot from a spring (S_1), passes through a loop-de-loop, travels up an incline, and hits and sticks to a second car (m_2). The pair of cars then compress a second spring (S_2) a distance of 4.20 cm, which trips a switch that rewards the player with 2000 points. The two cars then move off in a new direction.

The potential energy of a spring is $E_p = \frac{1}{2}kx^2$ where k is the spring constant and x is the distance the spring is compressed. Assume the system to be frictionless.

1. When a player operated the pinball machine, the spring (S_1) used to shoot the car was compressed 3.60 cm. The speed of the first car was 4.54 m/s as it left the spring. The spring constant k for S_1 is

A. 2.55×10^1 N/m
B. 1.16×10^2 N/m
C. 7.08×10^2 N/m
D. 3.21×10^3 N/m

2. Entering the bottom of the loop-de-loop, the car was travelling at 4.54 m/s. The speed of the car at the top of the loop-de-loop was

A. 8.84 m/s
B. 5.69 m/s
C. 2.97 m/s
D. 1.35 m/s

3. After the first car hit and stuck to the second car, they travelled toward S_2. This speed was too slow to compress S_2 4.20 cm. What is the minimum speed with which the cars after collision must be travelling in order for the player to receive 2000 points?

A. 2.72 m/s
B. 7.39 m/s
C. 54.6 m/s
D. 176 m/s

Use the following information to answer the next three questions.

When a motor vehicle slows down suddenly and the wheels are locked, the kinetic energy of the vehicle is transferred into heat energy. A skid mark is left on the road. Police can estimate the speed at which a vehicle was travelling before the brakes were applied by measuring the length of a skid mark d and applying the formula $v = \sqrt{2g\mu d}$, where $\mu = 0.750$ for a dry road surface.

After the brakes are applied and the wheels are locked, a 1.00×10^3 kg vehicle comes to a stop in 3.80 s. The vehicle leaves a 52.9 m skid mark.

Numerical Response

1. The estimated speed of the vehicle is calculated to be _________ m/s.

(Round and record your answer to three digits)

Numerical Response

*Use your **recorded answer** from **Numerical Response 1** to answer **Numerical Response 2.***

2. Assume a closed system between the vehicle and the road, such that the vehicle's kinetic energy is converted to heat. The amount of kinetic energy transformed into heat energy while the vehicle stops, expressed in scientific notation, is $\boldsymbol{b} \times 10^w$ J. The value of $\boldsymbol{b}$ is ___________.

(Round and record your answer to three digits.)

Numerical Response

*Use your **recorded answer** from **Numerical Response 1** to answer **Numerical Response 3.***

3. The magnitude of the impulse necessary to stop the vehicle, expressed in scientific notation, is $\boldsymbol{b} \times 10^w$ kg•m/s. The value of $\boldsymbol{b}$ is ___________.

(Round and record your answer to three digits.)

Use the following information to answer the next three questions.

Five cars were used in a test designed to study how injuries to the occupants of a car could be reduced.

Car	Mass (kg)
1	1740
2	2950
3	1770
4	2000
5	2040

4. Each car was designed with energy-absorbing crumple zones. Car 4, travelling at 100 km/h (27.8 m/s), was crashed into a wall and became 0.500 m shorter during impact. The average retarding force was

A. 1.36×10^6 N
B. 1.54×10^6 N
C. 1.57×10^6 N
D. 2.36×10^6 N

5. The automatic braking system in each car was designed to activate if the car encountered a sudden head-on force **equal to or greater than 1.25×10^4 N**. The activator uses an instrument that measures average force. In which cars would the braking system activate if each vehicle were forced to stop from 100 km/h in 4.0 s?

A. 1, 2, and 4
B. 1, 3, and 4
C. 2, 3, and 5
D. 2, 4, and 5

6. The 1740 kg car travelling north on an icy test area was crashed into the 2000 kg car travelling west. The test designers found that the two vehicles locked together on impact and slid at 9.0 m/s at 35° west of north. What was the speed of the 1740 kg car just before impact?

A. 16 m/s
B. 11 m/s
C. 8.5 m/s
D. 5.9 m/s

7. A clerk working at a local food store is asked to retrieve the empty shopping carts left outside by shoppers. Each cart has a mass of 20 kg. The clerk places 8 carts, which are locked together, close to the entrance on a slight incline. The clerk gathers another 12 carts and pushes them toward the store entrance. Meanwhile, the first 8 carts roll toward the 12 carts with a speed of 2.3 m/s. When the carts collide, they all come to a complete stop. At what speed were the 12 carts moving just before impact?

A. 2.88×10^{-2} m/s
B. 2.90×10^{-1} m/s
C. 1.53 m/s
D. 3.45 m/s

8. A 47.0 g golf ball is hit with an initial velocity of 70.0 m/s at an angle of 30.0° up from the horizontal. The vertical component of the ball's momentum is

A. 1.65 kg•m/s
B. 2.85 kg•m/s
C. 3.29 kg•m/s
D. 6.58 kg•m/s

9. Two railway cars, each of mass m, are approaching each other on a straight line with the same constant speed v. Their total kinetic energy E_k and total momentum $\vec{p}$ are

A. $E_k = mv^2, \quad \vec{p} = 2m\vec{v}$
B. $E_k = \frac{1}{2}mv^2, \quad \vec{p} = m\vec{v}$
C. $E_k = mv^2, \quad \vec{p} = 0$
D. $E_k = 0, \quad \vec{p} = 2m\vec{v}$

10. Two identical objects separated by 2.00×10^4 m have a gravitational attractive force equal to the electric force between a proton and an electron that are the same distance apart. What is the mass of each object?

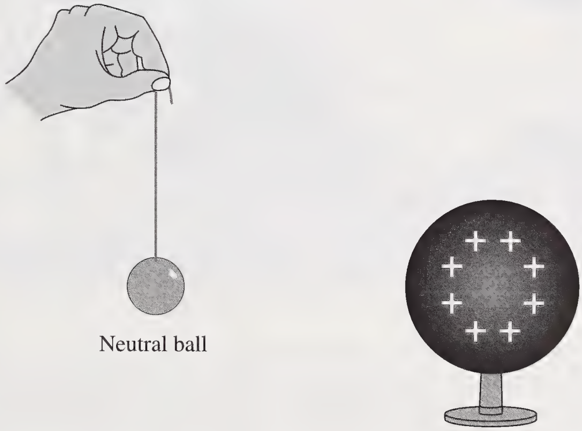
A. 1.24×10^{-19} kg
B. 3.45×10^{-18} kg
C. 1.86×10^{-9} kg
D. 4.64 kg

11. One of the differences between the phenomena related to Newton's law of universal gravitation and Coulomb's law is that

A. only one allows for a force of repulsion
B. the force–distance relationship is different
C. one deals with fields, the other with forces
D. only one requires a constant to describe the force

Use the following information to answer the next question.

Electrostatics



12. A neutral styrofoam ball covered with tinfoil is suspended by a thread and moved toward a charged metal sphere. The ball will be

A. unaffected by the sphere until it touches, then attracted
B. unaffected by the sphere until it touches, then repelled
C. attracted to the sphere until it touches, then repelled
D. repelled by the sphere before and after it touches

Use the following information to answer the next seven questions.

St. Elmo's Fire

On a hot summer day, a mountain climber attempts to reach the summit of a local mountain. Halfway, the climber stops on a ledge for a rest as large thunder clouds form overhead. Removing his backpack, he notices an eerie bluish glow, known as St. Elmo's Fire, surrounding the metal ice pick that is strapped onto the backpack. He quickly seeks shelter until the thunder clouds move away.

Continued

Numerical Response

4. The events that must occur in order for the phenomenon known as St. Elmo's Fire to appear are:

1. Air molecules nearest the ice pick separate into negative and positive ions.
2. Electrons in the metal ice pick concentrate near one end of the pick.
3. An electric field is created between the negative bottom of a cloud and the positive surface of Earth.
4. The negative and positive ions recombine, releasing energy as light.

Place the events in the correct sequence for the production of the eerie glow.

(Record your answer on the answer sheet □□□□.)

13. When the ice pick becomes charged, air molecules near it glow with an eerie blue light. This emission of bluish light is a result of

A. the air molecules becoming radioactive
B. electron transitions from lower energy levels to higher energy levels
C. the separation of O_2 and N_2 air molecules into positive and negative ions
D. electron transitions from higher energy levels to lower energy levels

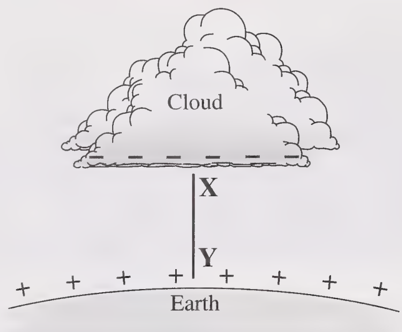
Numerical Response

5. If the blue light has a frequency of 7.50×10^{14} Hz, then the energy of a photon, expressed in scientific notation, is $b \times 10^{-w}$ J. The value of b is ____________ .

(Round and record your answer to three digits.)

Use this additional information to answer the next two questions.

Thundercloud

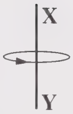


14. If the bottom of a cloud is relatively negative and the surface of Earth is relatively positive, then the direction of the resulting electric field, along line XY, can **best** be pictured as

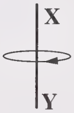
A.

B.

C.



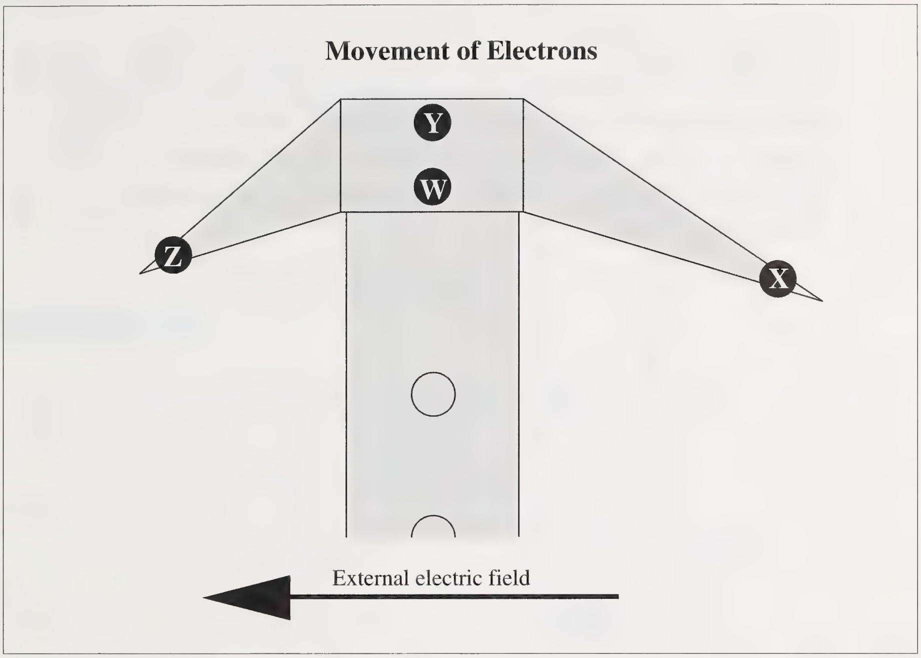
D.



15. Assume the bottom of the cloud and the surface of Earth are parallel and that they are separated by a distance of 2.00 km. If a potential difference of 5.00×10^8 V is created between the bottom of the clouds and the surface of Earth, the magnitude of the electric field created is

A. 2.50×10^5 V/m
B. 2.50×10^8 V/m
C. 1.00×10^9 V/m
D. 1.00×10^{12} V/m

Use this additional information to answer the next two questions.



16. If the ice pick is exposed to the external electric field, as shown above, electrons in the ice pick will move. In which area will there be the greatest concentration of electrons?

A. Z
B. Y
C. X
D. W

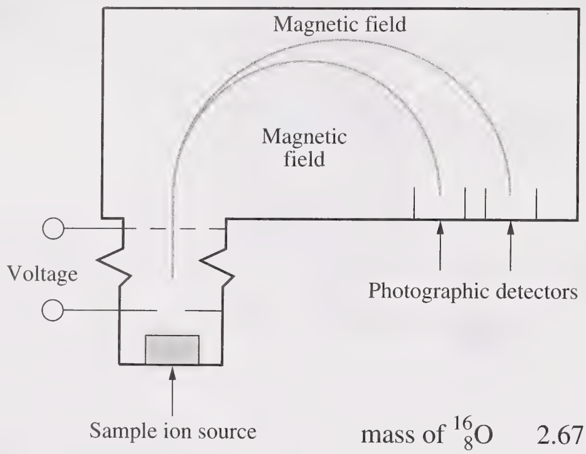
Numerical Response

6. If the magnitude of the external electric field is 1.20×10^{6} N/C, then the force on an electron in the ice pick, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ N. The value of $\boldsymbol{b}$ is ____________ .

(Round and record your answer to three digits.)

Use the following information to answer the next three questions.

There are two stable isotopes of oxygen, ${}^{16}_{8}O$ and ${}^{18}_{8}O$. The ratio of ${}^{16}_{8}O$ to ${}^{18}_{8}O$ in the ice of ancient glaciers is an indication of past temperatures. A mass spectrometer is used to measure the numbers of ${}^{16}_{8}O$ and ${}^{18}_{8}O$ atoms in a sample of ice. It uses a potential difference to accelerate the oxygen ions (O^{2-}) in a straight line. The path of the ions is then bent into circular motion by a magnetic field.



mass of ${}^{16}_{8}O$ 2.67×10^{-26} kg
magnetic field 1.01×10^{-1} T

17. The ions are negative. Therefore, to bend them into circular motion to the right, the direction of the magnetic field must be

A. into the page
B. out of the page
C. toward the top of the page
D. toward the bottom of the page

18. Which statement correctly describes the difference between the two isotopes of oxygen?

A. ${}^{18}_{8}O$ has 2 more protons than ${}^{16}_{8}O$
B. ${}^{18}_{8}O$ has 2 more neutrons than ${}^{16}_{8}O$
C. ${}^{18}_{8}O$ has 2 more electrons than ${}^{16}_{8}O$
D. ${}^{18}_{8}O$ has 2 fewer electrons than ${}^{16}_{8}O$

Numerical Response

7. The radius of the path for ${}^{16}_{8}O^{2-}$ ions that are moving at a speed of 2.00×10^{5} m/s, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ m. The value of $\boldsymbol{b}$ is ____________ .

(Round and record your answer to three digits.)

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19. If a current-carrying wire runs directly over a magnetic compass, the needle of the compass will

A. point in a direction perpendicular to the wire
B. point in a direction parallel to the wire
C. tend to point directly to the wire
D. not be affected by the current

Use the following information to answer the next two questions.

The energy of ultraviolet radiation can be harmful to living organisms by breaking the chemical bonds of DNA. The ozone layer provides protection from the UV radiation of the Sun. Each ozone molecule can absorb UV radiation having wavelengths less than 295 nm.

Numerical Response

8. Given the above data, the lowest frequency of ultraviolet light absorbed by an ozone molecule, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ Hz. The value of $\boldsymbol{b}$ is ____________ .

(Round and record your answer to three digits.)

Numerical Response

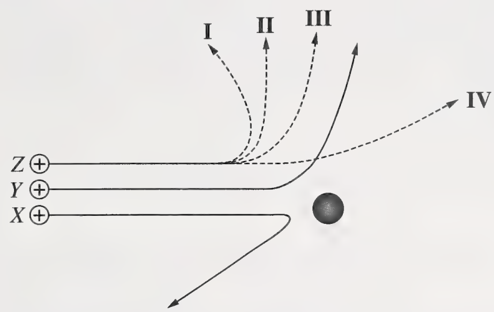
Use your ***recorded answer*** *from* ***Numerical Response 8*** *to answer* ***Numerical Response 9.***

9. The minimum energy of UV radiation absorbed by an ozone molecule will be $\boldsymbol{b} \times 10^{-w}$ J. The value of $\boldsymbol{b}$ is ____________ .

(Round and record your answer to three digits.)

Use the following information to answer the next question.

Scattering of Alpha Particles



Three alpha particles travelling at the same speed are deflected by the nucleus of a gold atom.

20. If particles X and Y are deflected as shown, particle Z will take path

A. I
B. II
C. III
D. IV

Numerical Response

10. Northern lights are often observed in Alberta skies. They occur as a result of a collision between electrons from the solar wind and oxygen atoms in the upper atmosphere. The oxygen atoms are excited after the collision. The most common colour, green, has a wavelength of 480 nm. To produce this colour, the electrons must be travelling with a minimum speed, expressed in scientific notation, of $\boldsymbol{b} \times 10^{w}$ m/s. The value of $\boldsymbol{b}$ is ____________ .

(Round and record your answer to three digits.)

21. A transformer has 4000 turns on the primary coil and operates at 400 V AC with a current of 0.460 A. Assuming 100% efficiency, if the secondary coil of the transformer has 200 turns, then the current in the secondary coil is

A. 23.0 A

B. 92.0 A

C. 0.023 A

D. 9.20 A

Use the following information to answer the next two questions.

An electrician has to install a step-down transformer that will be used to run a doorbell. The household supply voltage is 110 V (AC) and the doorbell requires only 16 V (AC).

22. If the doorbell draws 0.50 A of current, then the current drain from the household supply, assuming 100% efficiency, will be

A. 0.073 A

B. 0.29 A

C. 3.4 A

D. 14 A

23. On another circuit in the house, the primary coil of a different transformer draws 1.0×10^{-2} A. The transformer is only 95% efficient, losing energy to the environment due to heat and vibration. The total energy it will **lose** in 1.0 days is

A. 9.0×10^4 J

B. 4.8×10^3 J

C. 4.0×10^3 J

D. 2.0×10^2 J

Use the following information to answer the next three questions.

There is strong evidence that at least two planets are orbiting the pulsar neutron star PSRB 1257+12 in the constellation Virgo. The star emits radio waves that are detected with the 305 m diameter radio telescope in Puerto Rico. However, the orbiting planets' gravity causes the star to wobble in its rotation. The time it takes for the emitted radio waves to reach Earth varies.

24. One difference between radio waves and visible light is that radio waves

A. cannot be reflected
B. cannot travel through a vacuum
C. travel at a lower speed in a vacuum
D. have a longer wavelength than light

25. Radio waves from space longer than $\frac{1}{10}$ the diameter of the radio telescope are undetectable on Earth's surface because of atmospheric interference. What is the approximate lower limit of the frequency of detectable waves?

A. 1.0×10^{-7} Hz
B. 32 Hz
C. 9.8×10^{6} Hz
D. 9.2×10^{9} Hz

Numerical Response

11. When the radio waves arrive 3.1×10^{-3} s sooner than predicted, the pulsar's orbiting planets have pulled the source of radiation closer to Earth. The change in distance, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{\boldsymbol{cd}}$ m.

(Round and record your answer as $\boxed{a}\boxed{b}\boxed{c}\boxed{d}$.)

26. The energy that must be absorbed for an electron in a hydrogen atom to make the transition from the 5^{th} level to the 6^{th} level is

A. 0.17 eV
B. 0.38 eV
C. 0.54 eV
D. 0.92 eV

Use the following information to answer the next two questions.

This chart lists energy levels of the outer electron orbits in the sodium atom.

$n = \infty$	0.00 eV
•	•
$n = 6$	–1.10 eV
$n = 5$	–1.40 eV
$n = 4$	–1.60 eV
$n = 3$	–1.90 eV
$n = 2$	–3.00 eV
$n = 1$	–5.10 eV

27. The shortest wavelength of visible light emitted when an electron falls from the $n = 6$ level is

A. 2.40×10^{-7} m
B. 3.11×10^{-7} m
C. 1.10×10^{-6} m
D. 4.13×10^{-6} m

28. When its electron is in the lowest energy level, the sodium atom is said to be in the

A. ionized state
B. excited state
C. ground state
D. unstable state

Use the following information to answer the next two questions.

Gamma rays in astronomy are associated with processes that involve tremendous amounts of energy other than radioactive decay. Because detector efficiency of gamma rays is very poor at ground level, detection is done by satellite.

29. A gamma ray of frequency 1.75×10^{20} Hz is produced by a solar flare. What is the period of the ray?

A. 1.71×10^{-21} s
B. 5.71×10^{-21} s
C. 1.75×10^{20} s
D. 5.25×10^{28} s

30. A strong or intense source of gamma rays would **most likely** indicate that

A. an explosion had occurred
B. a strong gravitational field is present
C. energy is being converted into matter
D. matter is being converted into energy

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31. To what voltage would a cathode ray tube have to be adjusted to produce a photon that has a frequency of 3.00×10^{24} Hz?

A. 1.99×10^{-9} V
B. 1.24×10^{10} V
C. 3.00×10^{24} V
D. 1.88×10^{43} V

Use the following information to answer the next question.

A Japanese car manufacturer is designing an automatic braking system that detects objects in a car's path. The system involves a detector that receives reflected laser signals.

32. A signal sent by the laser is reflected and returned to the detector 0.15 μs after its transmission. The distance from the car to the detected object is

A. 15 m
B. 23 m
C. 42 m
D. 45 m

---

33. When light of frequency 5.0×10^{14} Hz illuminates a metal surface, photoelectrons are emitted with a maximum kinetic energy of 1.8×10^{-19} J. The threshold frequency of the metal is

A. 4.5×10^{11} Hz
B. 2.3×10^{14} Hz
C. 1.5×10^{19} Hz
D. 3.3×10^{19} Hz

Numerical Response

12. A 0.050 MeV X-ray beam is used to take a child's chest X-ray. The child's chest is 9 cm thick and the half-distance for this radiation in body tissue is 3 cm. The ratio of the energy received by the chest surface to the energy received by the skin on the child's back is ***a*** to ***b***.

(Record your answer as $\boxed{a}\boxed{b}\boxed{}\boxed{}$)

34. Gamma radiation is chosen for food irradiation because it

A. is safe, low-energy radiation
B. is the easiest form of radiation to produce
C. penetrates into the food through its packaging
D. poses no danger to the technologists doing the irradiation

Use the following information to answer the next three questions.

> In a number of nuclear power stations, the reaction material is Uranium 235. The ${}^{235}_{92}U$ will spontaneously decay to produce Thorium 231 plus at least one other particle. The half-life of ${}^{235}_{92}U$ is 7.0×10^{8} years.

35. One of the other particles that is produced during the decay process must be

A. an alpha particle
B. an electron
C. a neutron
D. a proton

36. How long would it take 10.0 g of ${}^{235}_{92}U$ to decay to 1.25 g in a nuclear reactor?

A. 9.9×10^{-2} y
B. 1.8×10^{8} y
C. 1.4×10^{9} y
D. 2.1×10^{9} y

37. The fission of ${}^{235}_{92}U$ will release 200 MeV of energy per atom. This energy is related to the

A. initial kinetic energy of the initiating neutron
B. conversion of a nucleon to energy
C. formation of beta radiation
D. mass defect of the nucleus

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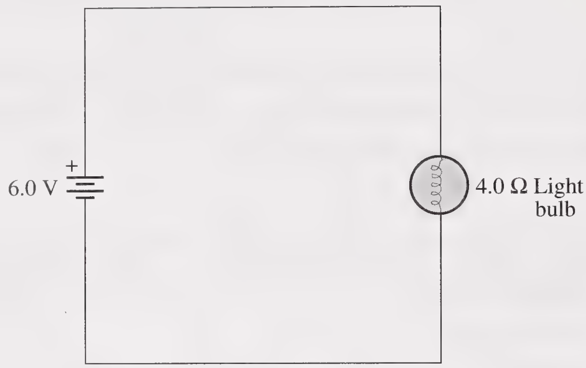
Written Response – 10 marks

Use the following information to answer written-response question 1.

Electrical Circuit



1. **a.** On the diagram above, correctly place and label the following six items. Show any additional wiring that is required to complete the circuit.

- a 3.0 Ω bulb in parallel with the 4.0 Ω bulb
- a 5.0 Ω bulb in series with both the 3.0 Ω and 4.0 Ω bulbs
- a switch to control the whole circuit
- a switch to control the 3.0 Ω bulb only
- a voltmeter to measure the potential difference across the 5.0 Ω bulb
- an ammeter to show the current passing through the 3.0 Ω bulb

For Department Use Only

b. Determine the total resistance of the circuit after the addition of these six items. Assume the switches are closed. (Show all the steps to your solution.)

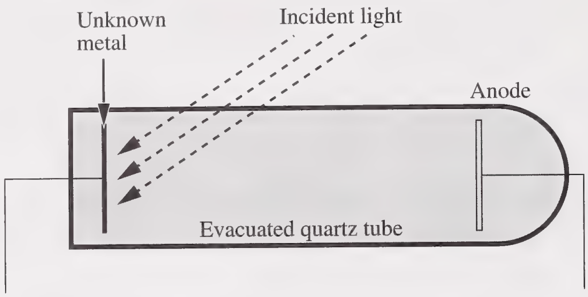
c. Calculate the voltmeter reading across the 5.0 Ω bulb. (Show all the steps to your solution.)

d. Calculate the ammeter reading for the current passing through the 3.0 Ω bulb. (Show all the steps to your solution.)

Written Response – 11 marks

Use the following information to answer written-response question 2.

The labels have fallen off two evacuated tubes that have unknown metals at each cathode. One tube, with Metal X as its cathode, detects visible light leakage from cameras. The other tube, with Metal Y as its cathode, detects ultraviolet leakage from shielded equipment. A student needs to know which tube is which. One of the evacuated tubes are shown below.



Also available is a variable-frequency electromagnetic wave source, a variable voltage source, a voltmeter, and any reference tables needed.

2. Design an experiment using the photoelectric effect to distinguish between Metal X and Metal Y. Your experimental design must contain:

- Statement of the purpose of the experiment
- List of the equipment needed
- A complete labelled diagram (above) of all the equipment necessary
- Procedure
- Measurements to be made and recorded, and any tables necessary
- Description of the analysis to be done
- An explanation using either the calculation or the derived algebraic equation showing how it will be used to distinguish between Metal X and Metal Y.

Note: A maximum of 8 marks will be awarded for the physics used in your design.
A maximum of 3 marks will be awarded for the effective communication of your response.

Continued

You have now completed the examination.
If you have time, you may wish to check your answers.

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PHYSICS DATA SHEETS

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity **or** Gravitational Field Near Earth	a_g <u>or</u> $g = 9.81\ \text{m/s}^2$ <u>or</u> $9.81\ \text{N/kg}$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$
Mass of Earth	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Radius of Earth	$R_e = 6.37 \times 10^{6}\ \text{m}$
Coulomb's Law Constant	$k = 8.99 \times 10^{9}\ \text{N}\bullet\text{m}^2/\text{C}^2$
Electron Volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
Elementary Charge	$e = 1.60 \times 10^{-19}\ \text{C}$
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum	$c = 3.00 \times 10^{8}\ \text{m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ <u>or</u> $-13.6\ \text{eV}$
Planck's Constant	$h = 6.63 \times 10^{-34}\ \text{J}\bullet\text{s}$
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11}\ \text{m}$
Rydberg's Constant for Hydrogen	$R_H = 1.10 \times 10^{7}/\text{m}$

Particles

	Rest Mass	**Charge**
Alpha Particle	$m_\alpha = 6.65 \times 10^{-27}\ \text{kg}$	α^{2+}
Electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	e^-
Neutron	$m_n = 1.67 \times 10^{-27}\ \text{kg}$	n^0
Proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	p^+

Trigonometry and Vectors

$$\sin\theta = \frac{opposite}{hypotenuse}$$

$$\cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

For any Vector $\vec{R}$

$$R = \sqrt{R_x^{\ 2} + R_y^{\ 2}}$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$R_x = R\cos\theta$$

$$R_y = R\sin\theta$$

Prefixes Used With SI Units

Prefix	Symbol	Exponential Value
pico	p	10^{-12}
nano	n	10^{-9}
micro	µ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}

Prefix	Symbol	Exponential Value
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}

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EQUATIONS

Kinematics

$$\vec{v}_{\text{ave}} = \frac{\vec{d}}{t}$$

$$\vec{a} = \frac{\vec{v}_{\text{f}} - \vec{v}_{\text{i}}}{t}$$

$$\vec{d} = \vec{v}_{\text{i}}t + \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \vec{v}_{\text{f}}t - \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \left(\frac{\vec{v}_{\text{f}} + \vec{v}_{\text{i}}}{2}\right)t$$

$$v_{\text{f}}^2 = v_{\text{i}}^2 + 2ad$$

Dynamics

$$\vec{F} = m\vec{a}$$

$$\vec{F}t = m\Delta\vec{v}$$

$$\vec{F}_{\text{g}} = m\vec{g}$$

$$F_{\text{f}} = \mu F_{\text{N}}$$

$$\vec{F}_{\text{s}} = -k\vec{x}$$

$$F_{\text{g}} = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{Gm_1}{r^2}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

$$F_{\text{c}} = \frac{4\pi^2mr}{T^2}$$

Momentum and Energy

$$\vec{p} = m\vec{v}$$

$$W = Fd$$

$$W = \Delta E = Fd\cos\theta$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_{\text{k}} = \frac{1}{2}mv^2$$

$$E_{\text{p}} = mgh$$

$$E_{\text{p}} = \frac{1}{2}kx^2$$

Waves and Light

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T = \frac{1}{f}$$

$$v = f\lambda$$

$$\frac{\lambda_1}{2} = l; \ \frac{\lambda_1}{4} = l$$

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\lambda = \frac{xd}{nl}$$

$$\lambda = \frac{d\sin\theta}{n}$$

$$m = \frac{h_{\text{i}}}{h_0} = \frac{-d_{\text{i}}}{d_0}$$

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_{\text{i}}}$$

EQUATIONS

Electricity and Magnetism

$$F_e = \frac{kq_1q_2}{r^2}$$

$$|\vec{E}| = \frac{kq_1}{r^2}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$|\vec{E}| = \frac{V}{d}$$

$$V = \frac{\Delta E}{q}$$

$$R = R_1 + R_2 + R_3$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$I_{eff} = 0.707\ I_{max}$$

$$V = IR$$

$$P = IV$$

$$I = \frac{q}{t}$$

$$F_m = IlB_\perp$$

$$F_m = qvB_\perp$$

$$V = lvB_\perp$$

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$V_{eff} = 0.707\ V_{max}$$

Atomic Physics

$$hf = E_{k_{max}} + W$$

$$W = hf_0$$

$$E_{k_{max}} = qV_{stop}$$

$$E = hf = \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$E_n = \frac{1}{n^2}E_1$$

$$r_n = n^2 r_1$$

$$N = N_0\left(\frac{1}{2}\right)^n$$

Quantum Mechanics and Nuclear Physics

$$E = mc^2$$

$$p = \frac{h}{\lambda}$$

$$p = \frac{hf}{c};\ \ E = pc$$

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No marks will be given for work done on this page.

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Tear-out Page

No marks will be given for work done on this page.

Physics 30
January 1996

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Physics 30

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